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A SOURCE MANUAL FOR INFORMATION ON NITINOL AND NiTi

FIRST REVISION

BY DAVID GOLDSTEIN

RESEARCH AND TECHNOLOGY DEPARTMENT

1 FEBRUARY 1980

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NAVAL SURFACE WEAPONS CENTER

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This manual is a current listing of most of the published literature on NITINOL and NiTi alloys. It includes a bibliography, titles of a group of NSWC unpublished internal reports and patents issued. Guidelines for obtaining licenses for Navy-owned patents and for technical assistance by the Navy are presented.

The manual is intended to aid scientists and designers in locating specific kinds of information on NITINOL shape-memory-effect alloys.

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FOREWORD

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The manual is intended to aid scientists and designers in locating specific kinds of information on NITINOL shape memory effect alloys.

Numerous additions have been made to both the Bibliography and Patent Listing in this first revision of the Source Manual, NSWC/WOL TR 78-26.

J. R. DIXON
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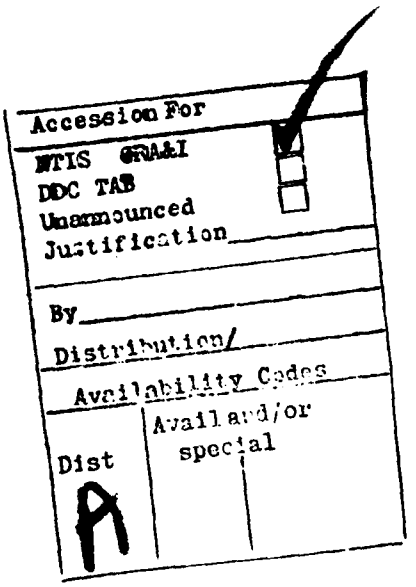

PREFACE

The broad applications for NITINOL and the diversity of publications in which the literature appears presents difficulty to those researching shape memory effect alloys. This manual is intended to alleviate the difficulty.

Literature titles on NITINOL are indexed by year of publication. This indexing system permits adding titles from the current year and from prior years.

CONTENTS

1. INTRODUCTION

NITINOL is the generic name which has been given to the family of alloys which are near NiTi in composition. They were developed in 1961 during an examination of ten different intermetallic compounds considered potentially useful as missile nose tip materials. The NiTi alloy exhibited what is now identified as a "shape memory effect" (SME).

The inventors of record, (Patent 3 174 851) W. J. Buehler and R. Wiley named the alloy family "NITINOL". This is derived from the chemical symbol "NiTi" followed by "NOL", the acronym for Naval Ordnance Laboratory, the prior designation of the Naval Surface Weapons Center.

As knowledge of the existence of this shape memory effect alloy broadens, so does the demand for knowledge of its properties. To assist those now entering the NITINOL technology community this source manual has been prepared.

The early years of research in this alloy concentrated on an understanding of the mechanism of the transformation and a comprehension of the overt SME behavior of the alloy. This was followed by commercial production of the alloy and the appearance of a narrow line of commercial products using the alloy. Simultaneously a large number of patents and ingenious new ways to utilize the alloy surfaced, but only a few were commerciallized.

Among the difficulties would-be entrepreneurs encountered were a lack of adequate NITINOL supplies in the shape and sizes desired, of selected transition-temperature and transition band widths at reasonable costs, and with prompt delivery. It has become clear that it is now in the Navy's interest to assist in the development of commercial applications for NITINOL. These will ultimately provide a self sustaining production base for alloy, as well as provide commercial sources of metal for low volume DOD applications.

It is against this background that the NITINOL Technology Center was activated in 1977 to explore low cost manufacturing technology for NITINOL and to assist in the development of NITINOL-using devices. The Center has a complete melting and fabricating facility for NITINOL.

For the development of NITINOL-using devices, the Technology Center offers guidance and/or prototype development programs. These

are usually joint efforts with other government agencies or commercial organizations. (Funding by the private sector for materials and/or services is permitted on a non-profit basis. Advance payment to the Commander, Naval Surface Weapons Center is required.) The facilities of NSWC are available to the NITINOL Technology Center, enabling complete design and fabrication of prototypes. This service is offered only if equivalent capability is not available from industry and is subordinate to Navy projects.

Current program emphasis is on manufacturing technology for NITINOL. Objectives are high quality wire and strip using existing commercial facilities. The output of this effort will be made available to designers and users for prototype devices and limited production runs.

2. LITERATURE SURVEY

Most of the publications listed here are available in open literature. Those with asterisks* following an identifier number may be ordered from the

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

NTIS also offers "Published Searches" of technical literature for $25 and "On Line" search for $100.

The NITINOL Technology Center maintains as complete a file of publications as possible. Duplication of specific articles can be arranged. Requests for assistance should be directed to:

Naval Surface Weapons Center
NITINOL Technology Center
Code CR-32
White Oak, Maryland 20910

Articles in the following bibliography are coded by the last two digits of the publication year, followed by the first letter of the principal author's name and a sequential number.

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3. INTERNAL REPORTS

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4. PATENTS

Copies of patents may be obtained from the

U.S. Patent Office
U.S. Dept. of Commerce
Box 9
Washington D.C. 20231

The cost of patents is 50 cents each. Patents which are Navy owned (including the basic patent on NITINOL) may be licensed. The

following statement from the Navy Office of Patent Counsel details licensing procedures.

LICENSES UNDER NAVY PATENTS AND PATENT APPLICATIONS

The Department of the Navy has instituted a program to license for commercial purposes patents and patent applications owned by the United States Government and in the custody of the Navy. This program is necessary because making, using or selling an invention covered by a Navy patent without express permission by the Government constitutes an unauthorized use. The Department of the Navy is presently implementing the Presidential Statement of Government Patent Policy of August 23, 1971.

A major premise of the Presidential Statement of Government Patent Policy, August 23, 1971 (36 FR 16887, August 26, 1971), is that Government inventions normally will best serve the public interest when they are developed to the point of practical application and made available to the public in the shortest possible time. The granting of express nonexclusive or exclusive licenses for the practice of these inventions may assist in the accomplishment of the national objective to achieve a dynamic and efficient economy.

The granting of nonexclusive licenses generally is preferable since the invention is thereby laid open to all interested parties and serves to promote competition in industry, if the invention is in fact promoted commercially. However, to obtain commercial utilization of the invention, it may be necessary to grant an exclusive license for a limited period of time as an incentive for the investment of risk capital to achieve practical application of an invention.

Whenever the grant of an exclusive license is deemed appropriate, it shall be negotiated on terms and conditions most favorable to the public interest. In selecting an exclusive licensee, consideration shall be given to the capabilities of the prospective licensee to further the technical and market development of the invention, his plan to undertake the development, the projected impact on competition, and the benefit to the Government and the public. Consideration shall be given also to assisting small business and minority business enterprises, as well as economically depressed, low income, and labor surplus areas, and whether each or any applicant is a U.S. citizen or corporation. Where there is more than one applicant for an exclusive license, that applicant shall be selected who is determined to be most capable of satisfying the criteria and achieving these goals.

The Chief of Naval Research (Code 302), Arlington, Virginia 22217, is now accepting applications for nonexclusive and exclusive

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All licenses will be individually negotiated with responsible applicants. The usual nonexclusive license will be revocable, non-transferable and royalty-free. The time period or term, the geographical area and/or field of use of the invention and other terms and conditions of the license are matters which will be considered in each case.

An applicant for a license should identify the patent or patent application number(s), state whether he is applying for a nonexclusive or an exclusive license, supply the name and address of the individual, organization or corporation (including the state of incorporation) applying for the license, provide a statement of the nature and type of the applicant's business and a statement of the purpose for which a license is desired along with a brief description of the applicant's plan to achieve that purpose including some indication of how the grant of a license would be in the public interest. Any other pertinent information should be included.

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Patent No. 3,174,851
"Nickel-Base Alloys"
W. Buehler and R. Wiley, Assignors to U.S.A.
Filed 1 Dec 1961
Issued 28 Mar 1965
3 Claims (Cl. 75-170)

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E. H. Frei, S. Leibinzohn and Shtrikman
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Filed 28 Aug 1965
Issued 7 Nov 1967
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D. M. Goldstein, W. J. Buehler and R. C. Wiley, Assignors to U.S.A.
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12 Claims (Cl. 29-191)

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8 Claims (Cl. 148-1.6)

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J. F. Johnson, D. Reiser and G. S. Ovrevik
9 Jul 1968
14 Claims (Cl. 244-1)

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10 Claims (Cl. 337-393)

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9 Claims (Cl. 72-47)

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2 Claims (Cl. 219-512)

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20 Claims (Cl. 73-339)

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3 Claims (Cl. 335-146)

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8 Claims (Cl. 75-135)

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Filed 30 Oct 1968
Issued 19 May 1970
22 Claims (Cl. 337-382)

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6 Claims (Cl. 340-227.1)

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19 Claims (Cl. 75-135)

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Issued 1 Jun 1971
2 Claims (Cl. 337-382)

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Filed 26 Feb 1968
Issued 20 Jul 1971
6 Claims (Cl. 148-13)

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Filed 13 Aug 1969
Issued 20 Jul 1971
25 Claims (Cl. 337-139)

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Filed 28 May 1969
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9 Claims (Cl. 337-140)

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J. R. Willson, K. T. Krueger, H. J. Tyler and W. F. Jackson, Assignors to Robertshaw Controls Co.
Filed 17 Jul 1969
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62 Claims (Cl. 137-625.44)

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R. D. Fannon, B. R. Lower and L. E. Laufe, Assignors to L. E. Laufe
File 15 Jun 1970
Issued 16 Nov 1971
8 Claims (Cl. 128-130)

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J. R. Willson, K. T. Kreuger, H. J. Taylor and W. F. Jackson, Assignors to Robertshaw Controls Co.
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28 Claims (Cl. 337-123)

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J. R. Willson and K. T. Krueger, Assignors to Robertshaw Controls Co.
Filed 19 Dec 1969
Issued 29 Feb 1972
9 Claims (Cl. 236-34)

Patent No. 3,652,969
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J. R. Willson and D. W. Carey, Assignors to Robertshaw Controls Co.
Filed 27 May 1969
Issued 28 Mar 1972
10 Claims (Cl. 337-140)

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A. Negishi, K. Takayanagi and M. Ikeda, Assignors to the Furukawa Electric Co., Ltd, Tokyo, Japan
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20 Claims (Cl. 236-93)

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1 Claim (Cl. 75-170)

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G. A. DuRocher, Assignor to Essex International, Inc.
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Issued 11 Jul 1972
17 Claims (Cl. 337-140)

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H. J. Tyler, Assignor to Robertshaw Controls Co.
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10 Claims (Cl. 337-140)

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Filed 10 Sep 1971
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3 Claims (Cl. 337-123)

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S. Abkowitz, J. M. Siergiej and R. R. Regan, Assignors to S. Abkowitz
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7 Claims (Cl. 75-170)

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3 Claims (Cl. 337-140)

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17 Claims (Cl. 337-139)

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H. M. White, Assignor to the U.S.A.
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R. F. Otte and C. L. Fischer, Assignors to Raychem Corp.
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16 Claims (Cl. 29-628)

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"Method for Stabilizing and Employing Temperature Sensitive Material Exhibiting Martensitic Transitions"
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Filed 14 Sep 1971
Issued 24 Jul 1973
7 Claims (Cl. 148-131)

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J. D. Harrison, J. Y. Choi and P. R. Marchant, Assignors to Raychem Corp.
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2 Claims (Cl. 75-134)

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13 Claims (Cl. 285-175)

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12 claims (Cl. 337-393)

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10 Claims (Cl. 337-382)

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R. F. Otte, Assignor to Raychem Corp.
Filed 4 Apr 1975
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13 Claims (Cl. 29-626)

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17 Claims (Cl. 29-447)

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16 Sep 1975

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15 Claims (Cl. 337-141)

Patent No. 3,913,326
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R. M. Banks, Assignor to the U.S.A.
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Issued 21 Oct 1975
9 Claims (Cl. 60-527)

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E. O. Olsen, Assignor to Foxboro Co.
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43 Claims (Cl. 318-676)

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21 Claims (Cl. 246-169A)

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"Thermal Engine"
E. Renner, Assignor to Vereinigte Flugtechnische Werke-Fokker GmbH
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15 Claims (Cl. 60-527)

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"Positioning Device using Negative Spring-Rate Tensioning Means"
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Filed 22 Feb 1974
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17 Claims (Cl. 60-528)

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21 Claims (Cl. 337-124)

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N. E. Rogen, Assignor to Nicoa Corp.
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8 Claims (Cl. 292-201)

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W. C. Stange, Assignor to the U.S.A.
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25 Claims (Cl. 340-224)

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12 Claims (Cl. 60/527-529)

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N. E. Rogen
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3 Claims (Cl. 187-17)

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F. W. Hill, Assignor to Raychem Limited
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10 Claims (Cl. 339-30)

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J. S. Cory
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38 Claims (Cl. 60-527)

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9 Claims (Cl. 60/527-529)

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25 Claims (Cl. 285-381)

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G. F. Andreasen, Assignor to the University of Iowa Research Foundation
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19 Claims (Cl. 32-14)

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28 Claims (Cl. 60-527)

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Filed 4 Jan 1973
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7 Claims (Cl. 220-201)

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Filed 16 Aug 1976
Issued 1 Nov 1977
25 Claims (Cl. 60-527)

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Y. T. Li, Assignor to Massachusetts Institute of Technology
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9 Claims (Cl. 60-527)

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W. K. Smith, Assignor to the U.S.A.
Filed 19 May 1975
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6 Claims (Cl. 60-527)

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4 Claims (Cl. 60-527)

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16 Claims (Cl. 174-52 FP)

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24 Claims (Cl. 75-134)

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R. J. T. Clabburn, Assignor to Raychem Limited
Filed 17 Jan 1978
Issued 17 Apr 1979
26 Claims (Cl. 148-11.5 R)

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